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# GEOECOLOGICAL ASSESSMENT OF THE NATURAL RESOURCES POTENTIAL IN LAKE GEOSYSTEMS OF THE BELARUSIAN POOZERYE

Hryszczankawa N. D. **Ocena geoekologiczna potencjału zasobów naturalnych geosystemów jeziornych Pojezierza Białoruskiego**. Przedstawiono wyniki oceny geoekologicznej potencjału zasobów przyrodniczych geosystemów jeziornych Pojezierza Białoruskiego. Ocena obejmuje cechy przestrzennego rozmieszczenia zasobów naturalnych, znaczenie zasobów jeziornych i poziom ich wykorzystania, a także omawia stan jezior. Jest to konieczne w celu opracowania regionalnej polityki racjonalnego wykorzystania przyrody.

Грищенкова Н. *Д.* **Геоэколгическая оценка природно-ресурсного потенциала озерных геосистем Белорусского Поозерья**. Приведены результаты геоэкологической оценки природно-ресурсного потенциала озерных геосистем Белорусского Поозерья. Оценка раскрывает особенности пространственного распределения природных ресурсов, значимости ресурсов озер и уровня их использования, а также экологического состояния озер, что необходимо для разработки региональной политики рационального природопользования.

**Key words**: natural resources potential, natural resources, geoecological assessment, Belarusian Poozerye, lake geosystem, use of lakes resources, environmental management, ecological status
**Słowa kluczowe**: potencjał zasobów naturalnych, zasoby naturalne, ocena geoekologiczna, Pojezierze Białoruskie, geosystem jeziorny, wykorzystanie zasobów jeziornych, racjonalne wykorzystanie przyrody, stan ekologiczny
**Ключевые слова**: природно-ресурсный потенциал, природные ресурсы, геоэкологическая оценка, Белорусское Поозерье, озёрная геосистема, использование ресурсов озёр, рациональное природопользование, экологическое состояние

Abstract

Results of a geoecological assessment of the natural resources potential in lake geosystems of the Belarusian Poozerye are given. The assessment opens features of spatial distribution of natural resources, the importance of lakes resources and level of their use, and also an ecological status of lakes that is necessary for development of regional policy of rational environmental management.

## INTRODUCTION

Natural resources potential belongs to the major categories of geoecology and environmental management. A plenty of works (MINC, 1972, MINC, KAKHANOVSKAYA, 1973; ISHMURATOV, 1979; MIKHAYLOV, 1980; ALAEV, 1983; RUDENKO, 1984; BAKLANOV, 2002; RUDSKIY, STURMAN, 2007) is devoted to definition and analysis of this concept. In all works a dual character of natural resources potential is marked. On the one hand, it is bodies and forces of the nature, and on the other – an economic value.

There are some types of natural resources potential assessments: economic, social, technological (industrial), physical-geographical and complex (including geoecological). The basic results of economic assessment (MINC, 1972; MINC, KAKHANOVSKAYA, 1973) are quantitative characteristics of various kinds of natural resources on the basis of common criteria; system-structural analysis of natural resources potential; an assessment of protection and renewal of natural resources, and also damage from environmental pollution.

The noneconomic assessment includes a definition of ecological, hygienic, socially-psychological, cultural, etc. values of natural resources, that is not expressed in economic parameters usually (a unique landscape, historical monuments), but can be conditionally estimated as the sum which the society can and is ready to offer for protection of the given natural resources (object). So, in social assessments the visible place be-

longs to medical and social criteria (RUNOVA, 1974; RUNOVA, VOLKOVA, NEFEDOVA, 1993). Technological assessments are used for the decision-making in construction, recreation, etc. In physical-geographical assessments the main attention is paid to the characteristic, comparison, classification of natural resources by their actual qualitative structure at the landscape level (RYUMIN, 1984; ISACHENKO, 2004, 2007).

As a sustainable development of any region is impossible without rational use of resources, the special importance was got to geoecological assessments recently. Their advantage is the complex approach, allowing to unite and consider all components (social, economic and natural) in their interrelation. The given approach is used in set of techniques of an assessment of environmental state and resources potential, but all of them are based on general scientific and particular methods of geoecological, physical-geographical, social and economic researches. A variety of approaches, terms and treatments, methods of calculation of parameters is marked in the literature (TROFIMOV, 1992; KOCHUROV, 1999; ZAIKANOV, MINAKOVA, SMIRNOVA, 2000; ISACHENKO, 2004, 2007; LIS, 2004; LOBKOVSKAYA, 2005; VITCHENKO, 2006; KOVAL, RUSH, 2006). Thus each approach demands adaptation to concrete territories and conditions.

The Belarusian Poozerye is characterized by great importance of lakes both in nature protection and economic issues. They concentrate abundant stocks of water, mineral, biological resources. Despite of significant number of researches executed by means of traditional approaches to an assessment of lakes resources (YAKUSHKO, 1999; VLASOV, 2004), they cannot satisfy modern practice needs. There are no complex approaches of assessment of natural resources potential of lake geosystems as the complete formations including lakes and adjoining to them territories. The assessment presented in the article allows to solve this problem.

## MATERIAL AND METHODS

Object of research – lake geosystems of the Belarusian Poozerye (Lakeland), including natural aquatic and territorial complexes. In the spatial attitude lake geosystems are presented by lakes and adjoining territories of administrative districts, where more than 50% of the area concern to the physical-geographical province of the Belarusian Poozerye. The given geosystems occupies 92% of territory of the province, differ the greatest lake percentage and lakes resources stocks in Belarus.

A special technique and geoinformation system of a geoecological assessment of the natural resources potential in lake geosystems was developed, that allow to make researches with groups of different parameters; the system of ranging and calculation of factors and indexes of the geoecological assessment based on a mark assessment method was proved and developed.

The conceptual model of the assessment consists of three evaluation units:

1) a definition of structure and size of the natural resources potential as a whole, and also separate kinds of resources (mineral, water, territorial, biological) in lakes and adjoining territories (fig. 1);
2) an assessment of an ecological status of lakes as the factor limiting use of their resources in economic activities, and a basis of natural functioning, protection of a biological and landscape diversity;
3) an assessment of a level of lakes resources use in economic activities as necessary basis for social development.

The determination of natural resources potential size is made by calculation of index values of stocks size of each natural resource in a district, cumulative sizes of each of kind of resources and sizes of natural resources potential as a whole. The parameters describing resources of territories and lakes, as the corresponding sums of indexes by separate kinds of resources, and also the factors determining specific sizes of resources of territories and lakes (in %) in total size of natural resources potential of lake geosystem and a ratio of resources of lakes and territories are calculated.

At a following stage the economic activities in which various resources of lakes are used are defined (table 1). On the basis of the received values the degree (in %) of use of each lake resource in economic activities in the general size of this resource in lakes of a district, indexes of use of this resource in relation to the average regional level and an integrated index of lakes resources use in a district are calculated. Complexity of lakes resources use is defined by quantity of activities in which they are used.

It is necessary to consider as well the ecological restrictions directed on rational use of resources and protection of lakes from pollution and degradation. For this purpose the assessment of an ecological status of lakes and their transformation is made. It includes a hydrochemical, geochemical and hydrobiological evaluation units.

## RESULTS AND THEIR DISCUSSION

During the assessment quantitative characteristics of various kinds of natural resources (mineral, water, biological, territorial) in the Belarusian Poozerye we-

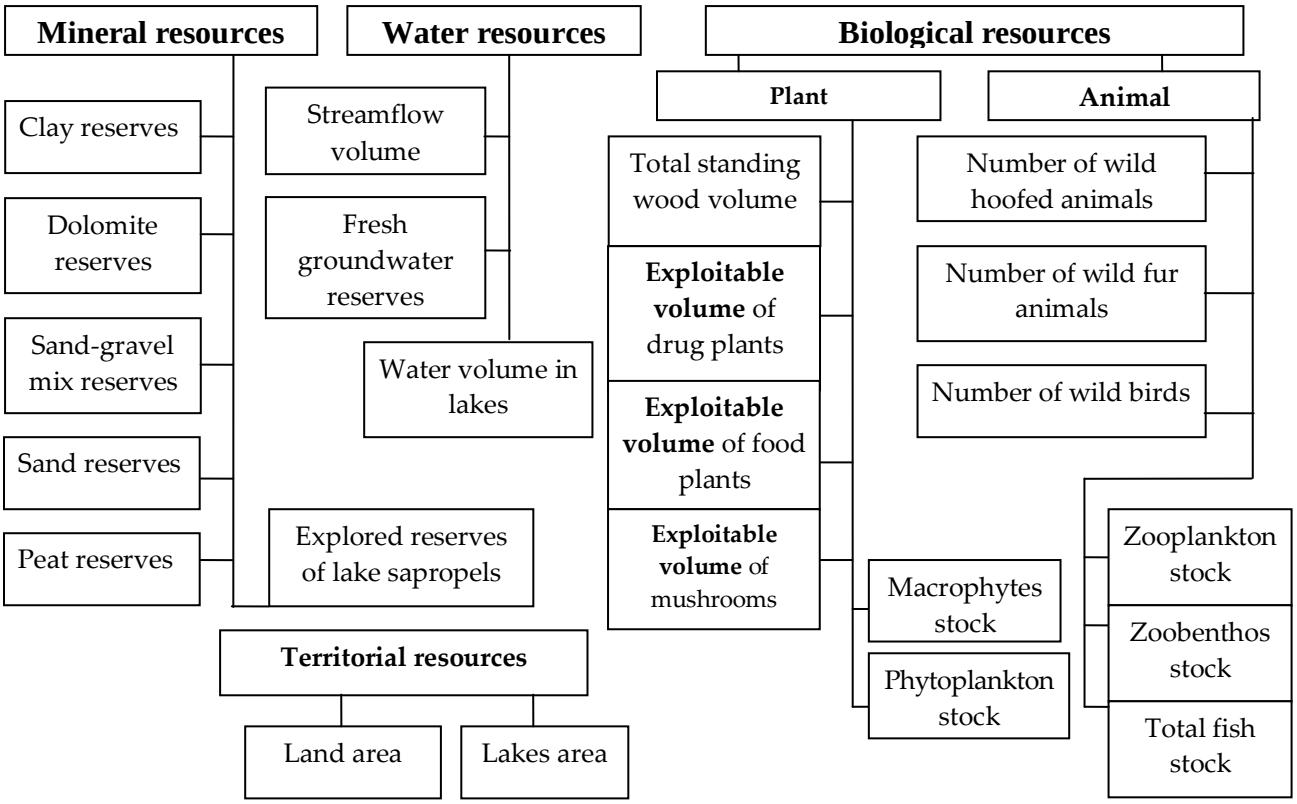



Fig. 1. Structure of parameters of the basic kinds of natural resources
Rys. 1. Struktura elementów głównych rodzajów zasobów naturalnych

Table 1. Parameters of lakes resources use
Tabela 1. Elementy wykorzystania zasobów jeziornych

| Direction of use | Parameters |
|---|---|
| Industrial and production | Volume of the water used for industrial needs |
| Agricultural | Volume of the water used for agricultural needs |
| Household | Volume of the water used for household and drinking needs |
| Commercial fishing | Volume of the water used on pond fish establishment<br>Commercial fish catch |
| Recreational and medical | Holding capacity of recreational and sanatorium objects located on lakes coast |
| Nature protection | Area of protected territories based on lakes |
| Resource development | Extraction of sapropels<br>Preparation of macrophytes<br>Preparation of phytoplankton<br>Preparation of zooplankton<br>Preparation of zoobenthos |

re defined, regularities of their territorial differentiation were identified, the part of lakes resources in the natural resources potential was defined and the estimation of a level of their economic use was made.

## Mineral resources

The territory of the region is rich with stocks of overspreaded minerals: dolomite, clay, sand, sand-gravel mix, peat. Resources of lakes are presented by mineral (sand, clay), organic-mineral (silty muds, sapropels) and organic sediments (sapropels, peat). By virtue of specificity of a geographical position and an accessory of lakes to humid zone organic resources of lakes – sapropels – are of the greatest interest mostly because of their most perspective use. Their basic stocks (1,65 billion $m^3$) are located in the Poozerye (454 lakes) (fig. 2). The stocks include silica – 75,5%, organic – 13,9%, carbonate – 6,0% and mixed sapropels – 4,6%.

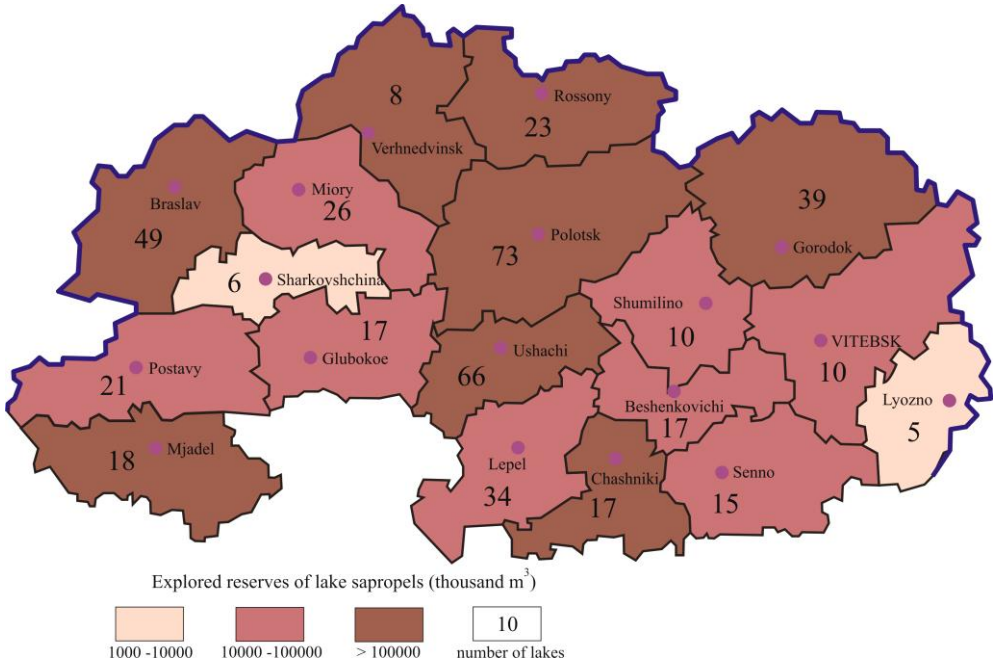



Fig. 2. Reserves of lake sapropels in the Belarusian Poozerye
Rys. 2. Zasoby sapropelu na Pojezierzu Białoruskim

The districts with the highest index of mineral resources stocks are Vitebsky, Chashniksky, Gluboksky, Gorodoksky, Beshenkovichsky, Shumilinsky, that is explained by large stocks of dolomite in Vitebsky, clay – in Chashniksky and Shumilinsky, sand-gravel mix – in Gluboksky and Gorodoksky, sand – in Beshenkovichsky district. Braslavsky and Verhnedvinsky districts possess the most abundant stocks of sapropels in the region (261,7 and 190,6 million m$^3$ accordingly). The part of lakes resources (sapropels) in total amount of mineral resources exceeds 50% for Braslavsky and Rossonsky districts (fig. 3).

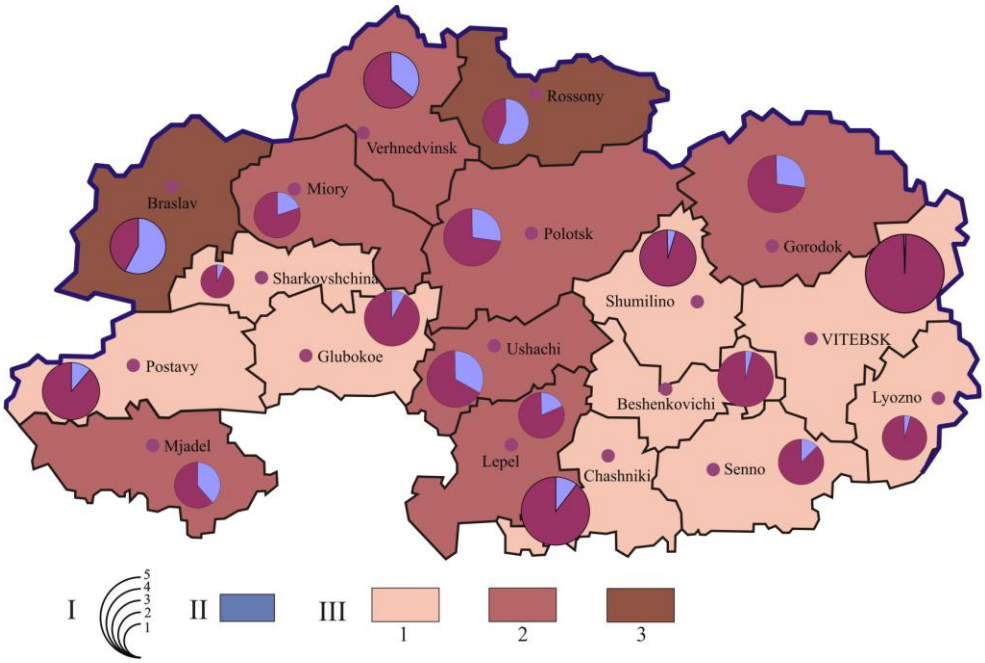



Fig. 3. Stocks of mineral resources in the Belarusian Poozerye:
I – stocks of mineral resources (index): 1 – less than 2,0; 2 – 2,0–4,0; 3 – 4,1–8,0; 4 – 8,1–14,0; 5 – more than 14,0;
II – a part of lakes resources in total amount of mineral resources in a district; III – a factor of mineral resources ratio:
1 (less than 0,2), 2 (0,2–1,0), 3 (more than 1,0)
Rys. 4. Zasoby mineralne Pojezierza Białoruskiego:
I – zasoby mineralne (indeks): 1 – poniżej 2,0; 2 – od 2,0 do 4,0; 3 – od 4,1 do 8,0; 4 – od 8,1 do 14,0; 5 – powyżej 14,0; II – udział zasobów jeziornych w ogólnej masie zasobów mineralnych pojezierza; III – współczynnik wzajemnego stosunku zasobów mineralnych: 1 (poniżej 0,2), 2 (0,2–1,0), 3 (powyżej 1,0)

## Water resources

The region has the greatest water storage in the republic. There are 2 300 lakes nearby with a total area more than 1000 km², 240 small rivers with a general length more than 9 000 km, one big river – Zapadnaya Dvina. The balance reserves of fresh groundwater are 763 000 m³/day. One of the basic natural resources of lakes in the region is water storage. The area of lakes varies within the limits of 0,001 – 79,62 km². The basic amount of them have an area less than 0,1 km² (44,7%) and 0,1–1,0 km² (44,0%). The part of lakes with an area 1–10 km² is 10,2% only. The quantity of largest lakes is sharply reduced with an increase of their area (fig. 4).

The water volume in lakes of the region is 4 804,86 million m³. It changes from 0,0057 up to 710 million m³ in a lake. The majority of lakes (88,3%) have water volume less than 10 million m³. Lakes with a volume more than 10 million m³ make 11,7%.

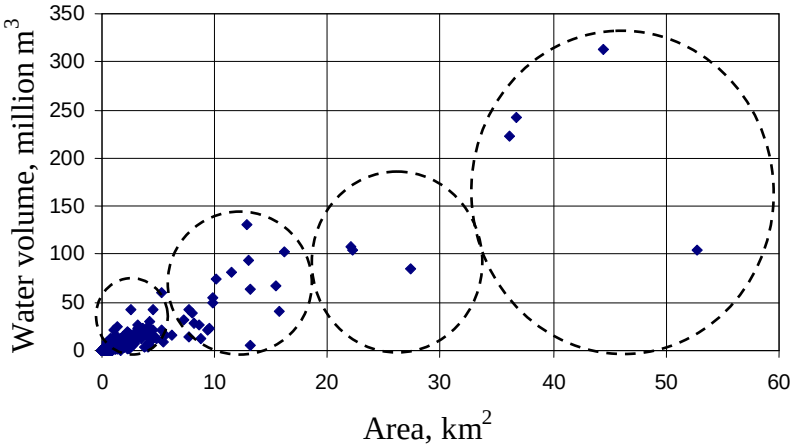



Fig. 4. Distribution of lakes of the Belarusian Poozerye by water volume and area (without lake Naroch)
Rys. 4. Rozmieszczenie jezior na Pojezierzu Białoruskim wg ich objętości i powierzchni (bez jez. Narocz)

The districts with the highest index of water storage are Vitebsky, Polotsky, Myadelsky, Braslavsky, Gorodoksky; the minimal is in Sharkovshchinsky district. The greatest water volume in lakes is in Myadelsky (987,98 million m³) and Braslavsky (973,78 million m³) districts, than in Gorodoksky, Ushachsky, Polotsky, Rossonsky, Chashniksky and Lepelsky districts (fig. 5). The part of lakes resources in total amount of water storage exceeds 50% for Braslavsky, Myadelsky, Ushachsky and Chashniksky districts (fig. 6).

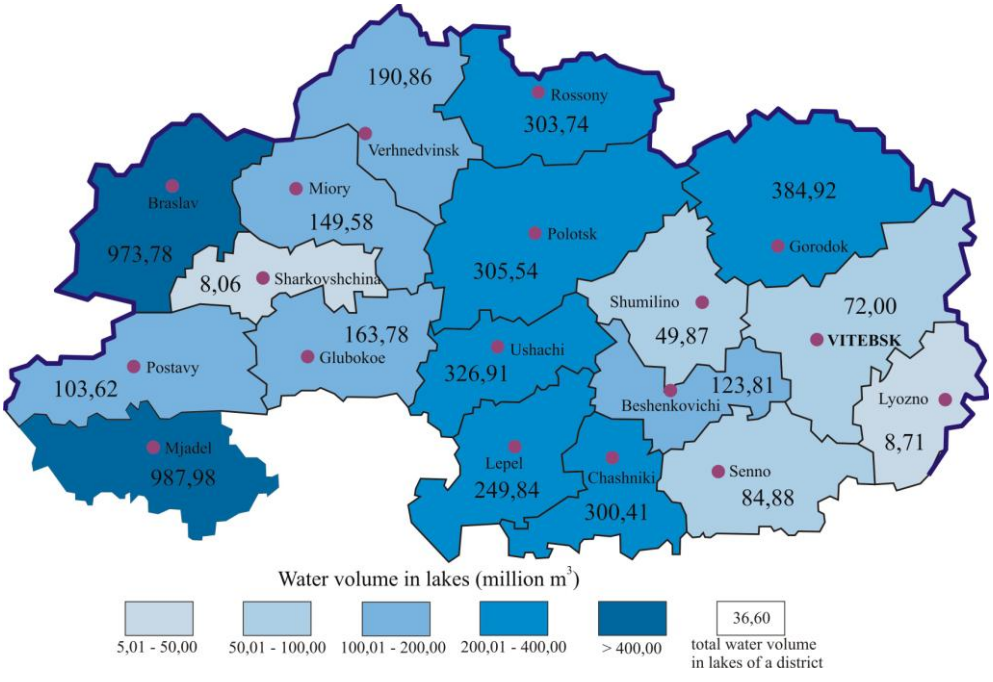



Fig. 5. Water volume in lakes of the Belarusian Poozerye
Rys. 5. Objętość wody w jeziorach Pojezierza Białoruskiego

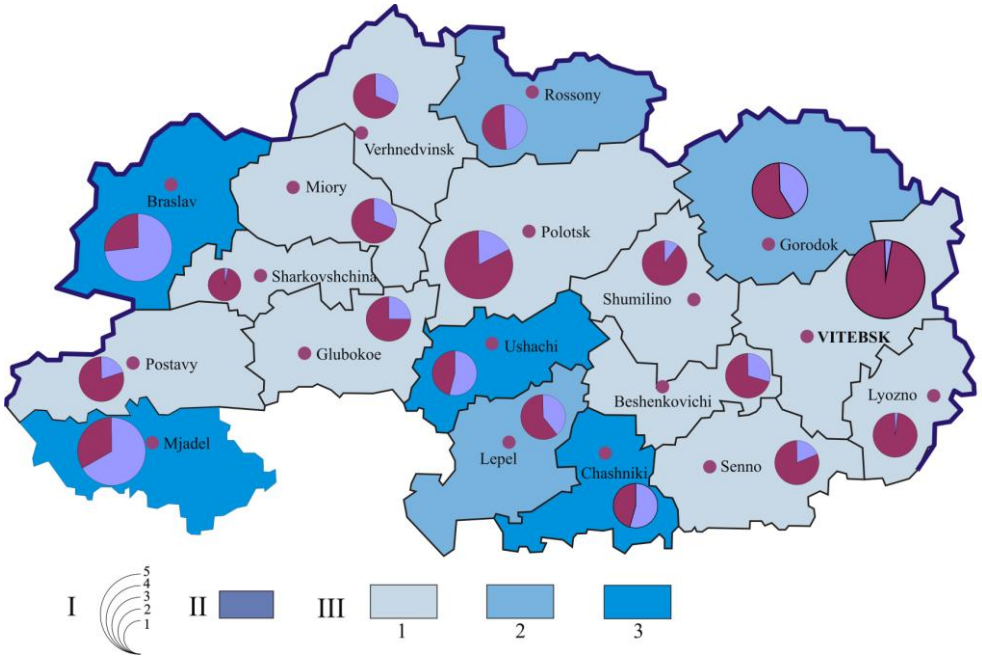



Fig. 6. Water storage of the Belarusian Poozerye:
I – water storage (index): 1 – less than 1,0; 2 – 1,0–3,0; 3 – 3,1–5,0; 4 – 5,1–7,0; 5 – more than 7,0; II – a part of lakes resources in total amount of water resources in a district; III – a factor of water resources ratio: 1 (less than 0,5), 2 (0,5–1,0), 3 (more than 1,0)

Rys. 6. Zasoby wody na Pojezierzu Białoruskim:
I – zasoby wodne (indeks): 1 – poniżej 1,0; 2 – od 1,0 do 3,0; 3 – od 3,1 do 5,0; 4 – od 5,1 do 7,0; 5 – powyżej 7,0; II – zasoby wodne jezior w ogólnej objętości zasobów wodnych pojezierza; III – współczynnik wzajemnego stosunku zasobów wodnych: 1 (poniżej 0,5), 2 (0,5–1,0), 3 (powyżej 1,0)

## Territorial resources

The total area of the region is 3 510 500 hectares, under lakes – 106 000 hectares (3%). In the administrative attitude the basic amount of lakes (about 60%) is concentrated in Polotsky, Miorsky, Braslavsky, Rossonsky, Ushachsky, Myadelsky and Gorodoksky districts. The largest lakes of the region – Naroch, Osveyskoye, Lukomskoe, Dryviaty, Neshcherdo, Snudy, Ezeryshche, Strusto, Obsterno. For example, there are 235 lakes (8,0% of the total area) in Braslavsky district, 56 lakes (7,5% of the total area) in Myadelsky district. High lake cover persantage is characteristic for Verhnedvinsky (3,8%), Chashniksky (4,0%), Rossonsky (4,1%) and Ushachsky (5,1%) districts (fig. 7).

The districts with the highest index of territorial resources are Braslavsky, Mjadelsky, Polotsky, Gorodoksky. The part of lakes resources in total amount of territorial resources exceeds 50% for Braslavsky, Myadelsky, Verhnedvinsky, Ushachsky, Chashniksky and Rossonsky districts (fig. 8).

## Plant resources

The total area of the region covered by forests is 1,44 million of hectares (42%). Percentage of forest land is the largest in Polotsky and Rossonsky districts, here it reaches 62%. The forest area is much less (15–40%) on heights. The total standing wood volume is 265,3 million $m^3$. There are significant volumes of wild berries (a cranberry, a bilberry, a cowberry, a blueberry, a raspberry, a wild strawberry, a blackberry) – 8 273 tons; mushrooms (an aspen mushroom, a cep, a birch mushroom, a mossiness mushroom, a chanterelle, a honey agaric, a milk mushroom, etc.) – 5 382 tons; drug plants – 61 403 tons.

The basis of plant resources of lakes in the region is made by higher aquatic plants (macrophytes) and phytoplankton. The specific structure, quantitative development and distribution of macrophytes depend on features of lake hollow, physical and chemical properties of water and sediments. Lakes with low mineralization and attributes of oligotrophic, dystrophic and megatrophic lakes are characterized by poor specific structure (less than 10 species), eutrophic – by average structure (10–30 species), mesotrophic – by rich (more than 30 species).

The greatest amount of lakes in the region (68,5%) have a low and moderate degree of macrophytes covering (10-40%). The lakes with well developed submersed vegetation (41–100%) make 31,5% from the studied amount, about 17% them are highly and completely overgrown (more than 80%).

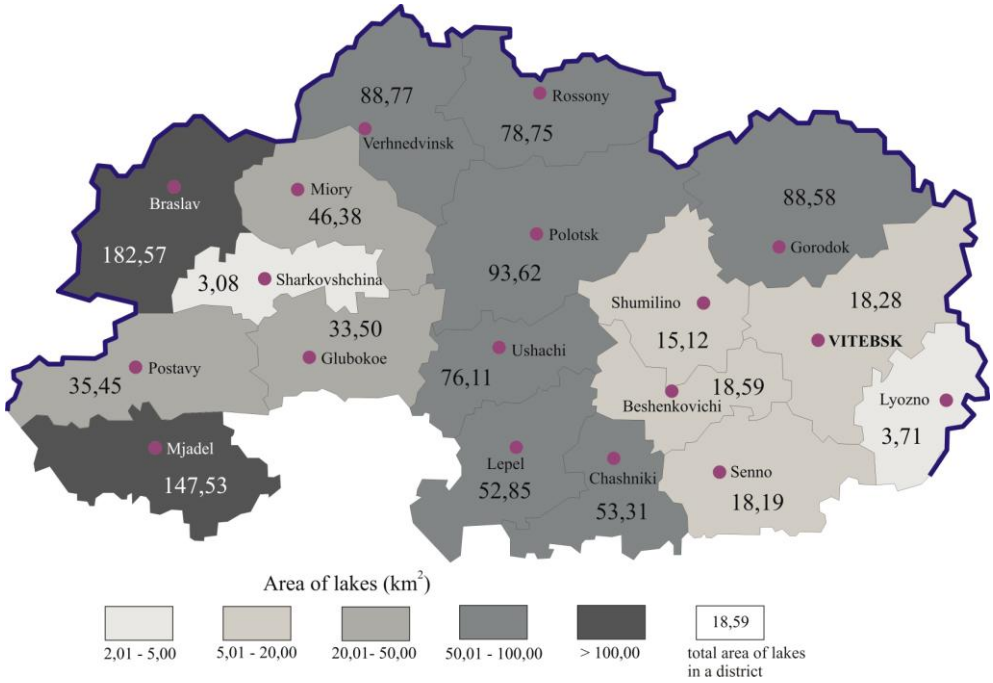



Fig. 7. Area of lakes in the Belarusian Poozerye
Rys. 7. Powierzchnia jezior Pojezierza Białoruskiego

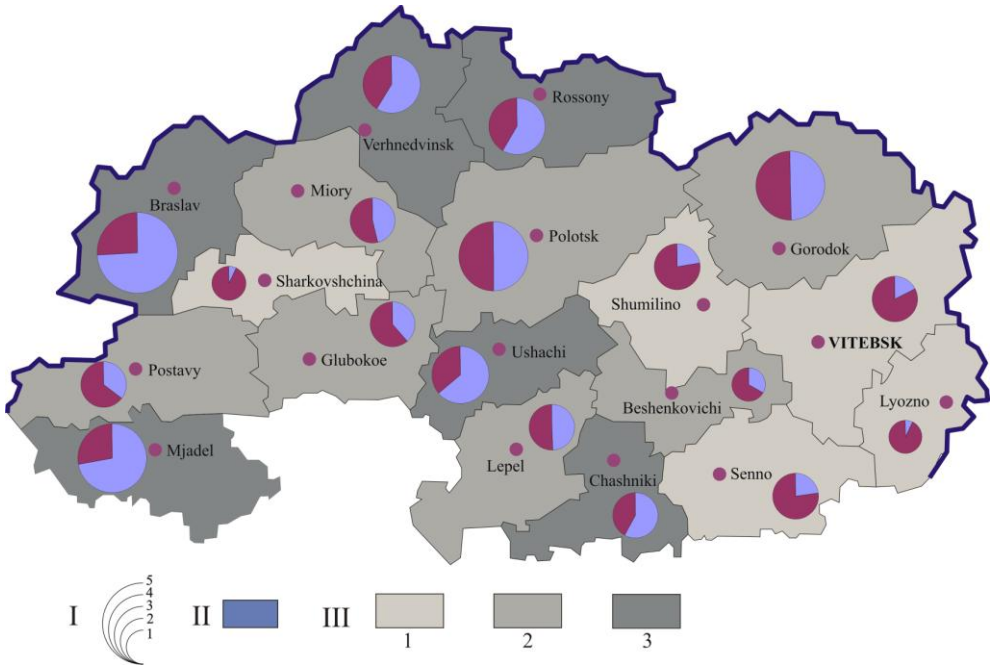
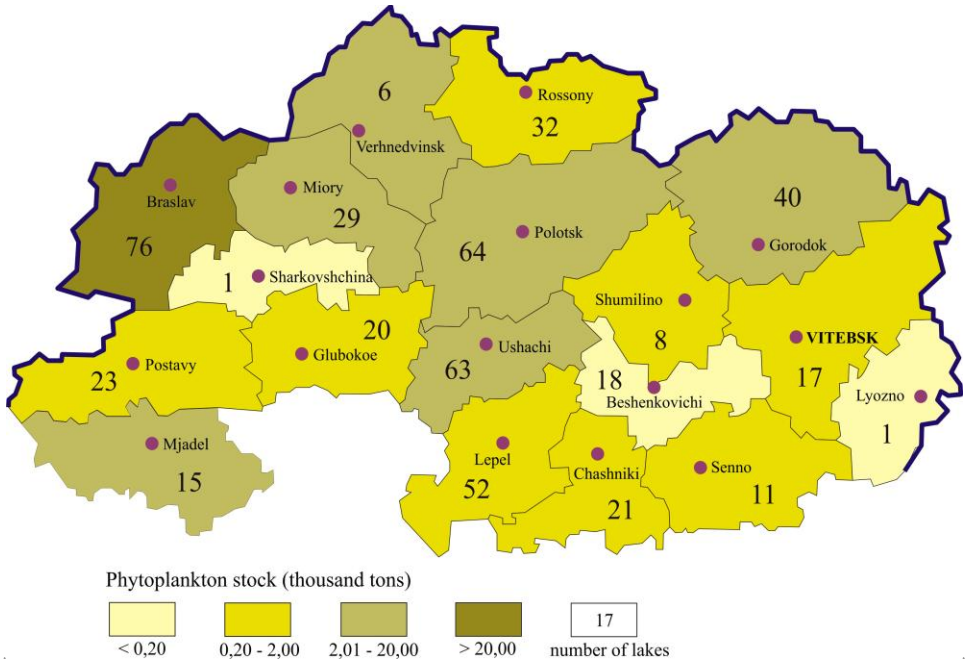


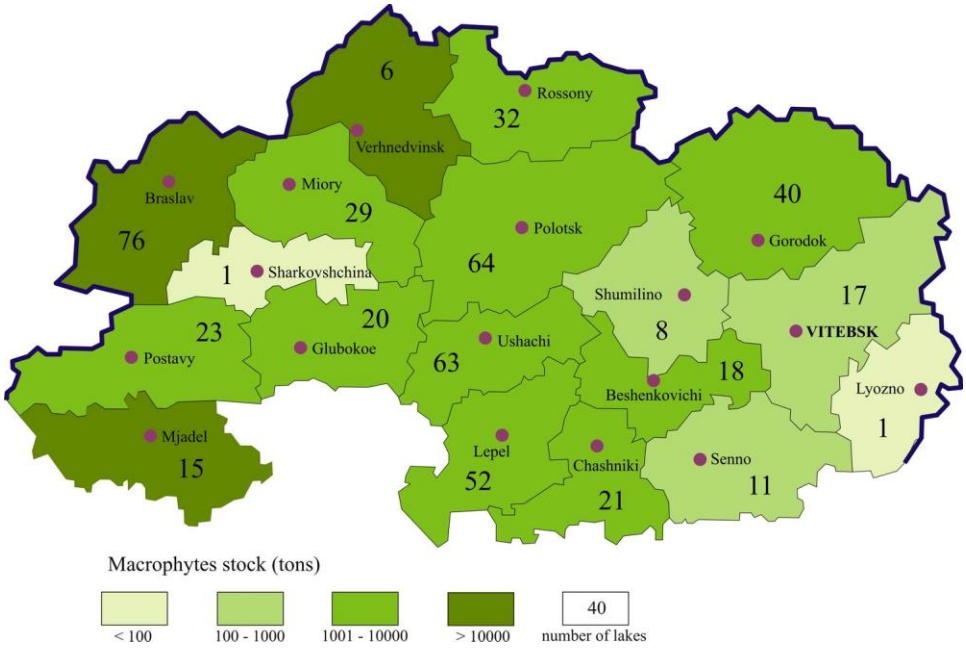

Fig. 8. Territorial resources of the Belarusian Poozerye:
I – territorial resources (index): 1 – less than 1,0; 2 – 1,0-2,0; 3 – 2,1-3,0; 4 – 3,1-4,0; 5 – more than 4,0; II – a part of lakes resources in total amount of territorial resources in a district; III – a factor of territorial resources ratio: 1 (less than 0,5), 2 (0,5-1,0), 3 (more than 1,0)
Rys. 8. Zasoby wielkości powierzchni Pojezierza Białoruskiego:
I – zasoby wielkości powierzchni (indeks): 1 – poniżej 1,0; 2 – od 1,0 do 2,0; 3 – od 2,1 do 3,0; 4 – od 3,1 do 4,0; 5 – ponad 4,0;
II – udział zasobów jeziornych w ogólnej masie zasobów wielkości powierzchni pojezierza; III – współczynnik wzajemnego stosunku zasobów wielkości powierzchni: 1 (poniżej 0,5), 2 (0,5–1,0), 3 (powyżej 1,0)

The biomass of macrophytes changes within the limits of 0,01–0,5 kg of air-dry weight on 1 m². A half from the studied lakes of the region have low and very low biomass of macrophytes (less than 0,21 kg), 47,3% of lakes – moderate (0,21–0,40 kg), and only 1,8% of lakes – a high biomass (more than 0,40 kg). The general macrophytes stock of 496 most overgrown lakes of the Belarusian Poozerye is about 90 000 tons of air-dry weight. More than half from these lakes (58,9%) concern to helophytic, 15,3% – to helohydrophytic, 25,8% – to hydrophytic type of overgrowth. The basic stocks are concentrated in 76 lakes of helohydrophytic type (24 236,3 tons), 69 hydrophytic pondweed lakes (23 040,2 tons) and 30 hydrophytic chara lakes (18 348,4 tons); less stocks are in 92 helophytic bulrush lakes (12 533,9 tons) and 147 helophytic reed-bulrush lakes (10 647,0 tons). The lakes of other subtypes grow poorly, have a low biomass of macrophytes and low economic value accordingly.

The basic macrophytes stocks are concentrated in lakes of Braslavsky (17 767,9 tons), Verhnedvinsky (11 685,7 tons) and Myadelsky (10 970,2 tons) districts (fig. 9).

A




B

Fig. 9. Stocks of plant resources in lakes of the Belarusian Poozerye (A – phytoplankton, B – macrophytes)
Rys. 9. Zasoby roślinne w jeziorach Pojezierza Białoruskiego (A – fitoplankton, B – makrofity)

The biomass of phytoplankton in lakes of the region changes from 0,03 up to 150 gr/m$^3$ and more. The highest biomass (more than 8 gr/m$^3$) is in megatrophic lakes, the lowest – in lakes of oligo-mesotrophic type. 6,9% of lakes have very low biomass of phytoplankton (less than 0,5 gr/m$^3$), 12,2% – low (0,5–1,0), 38,4% – moderate (1,01–4,0), 11,4% of lakes – very high biomass (more than 16 gr/m$^3$). The basic resources of phytoplankton are concentrated in lakes of Braslavsky (20 219 tons), Ushachsky (15 866 tons) and Gorodoksky (8 488 tons) districts (fig. 9).

The districts with the highest index of plant resources are Polotsky, Braslavsky, Gorodoksky, Rossonsky and Lepelsky. The part of lakes resources in total amount of plant resources exceeds 50% for Braslavsky, Ushachsky, Chashniksy districts (fig. 10).

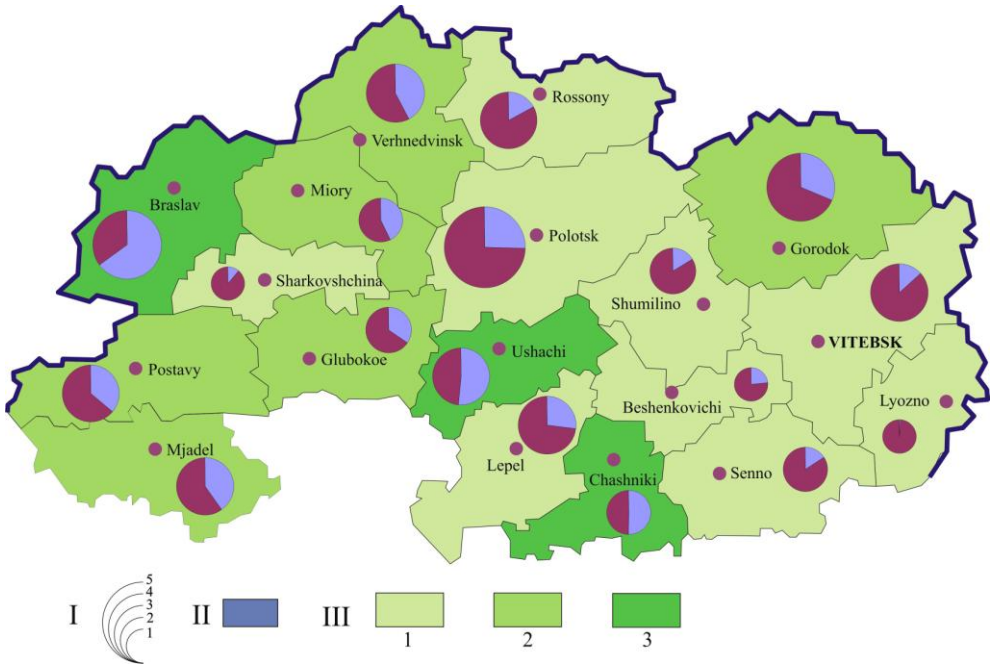


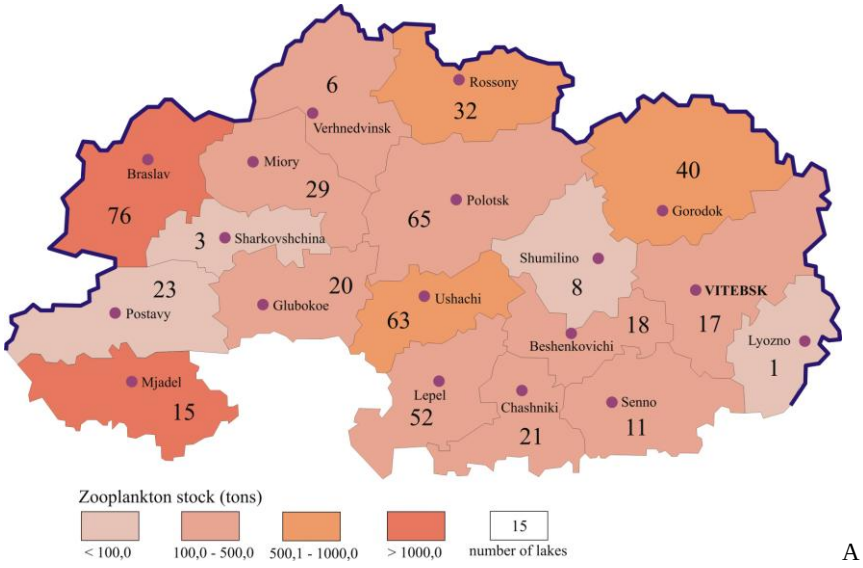

Fig. 10. Stocks of plant resources in the Belarusian Poozerye:
I – plant resources stocks (index): 1 – less than 3,0; 2 – 3,0-6,0; 3 – 6,1-9,0; 4 – 9,1-12,0; 5 – more than 12,0;
II – a part of lakes resources in total amount of plant resources in a district; III – a factor of plant resources ratio: 1 (less than 0,5), 2 (0,5-1,0), 3 (more than 1,0)

Rys. 10. Zasoby roślinne Pojezierza Białoruskiego:
I – zasoby roślinne (indeks): 1 – poniżej 3,0; 2 – od 3,0 do 6,0; 3 – od 6,1 do 9,0; 4 – od 9,1 do 12,0; 5 – powyżej 12,0;
II – udział zasobów jeziornych w ogólnej masie zasobów roślinnych pojezierza; III – współczynnik wzajemnego stosunku zasobów roślinnych: 1 (poniżej 0,5), 2 (0,5–1,0), 3 (powyżej 1,0)

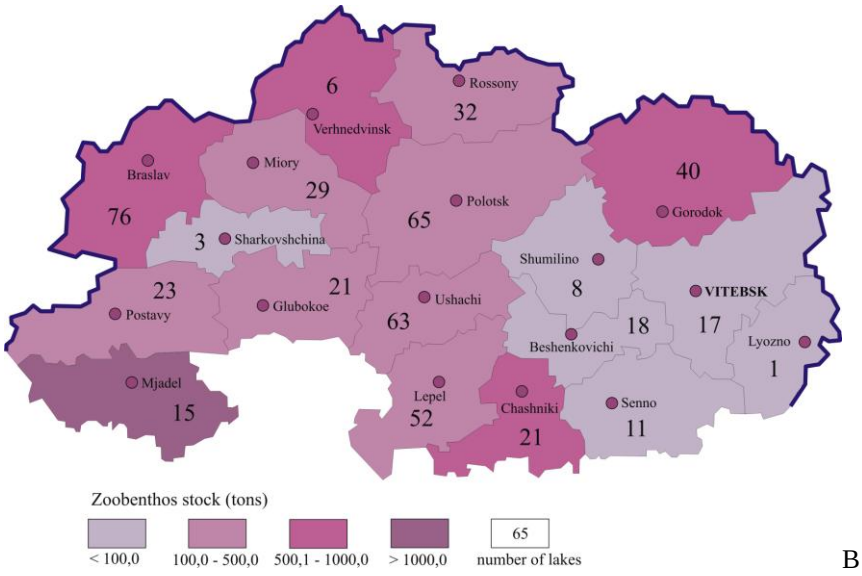
## Animal resources

Fauna of the region can be considered first of all as a resource of trade production, sport hunting and fishery, cognitive tourism (hunting with a camera, visiting of open-air cages, supervision over animals in their natural habitats). The basic hunting-commercial species among mammals are a wild boar, an elk, a roe deer, a deer, a beaver, a squirrel, a muskrat, a brown hare, a mountain hare, a wolf, a fox, a racoon dog, a marten, a polecat, an American mink, a mole. Their number in the region is the highest in the republic. There is 27,9% of number of an elk, 19,2% – of a wild boar, 25,5% – of a beaver, 20,5% – of a hare, 22,3% – of a squirrel, 36,0% – of a mink in the region from the total in the country. The species included in the Red Book (a brown bear, a badger, a lynx) represent a special interest for hunting with a camera and cognitive tourism. Among birds it is necessary to note a blackcock and a wood-grouse, which number and density in the region is the highest in the republic (27 and 51% accordingly). The species that are resolved for hunting (a mallard, a teal, a tufted duck, a bald-coot, a duck) are widespread. The quantity of rare for the Europe birds (a black-throated diver, an osprey, a white-tailed eagle, a golden eagle, a peregrine falcon, a ptarmigan) is great.

To estimate animal resources in lakes is rather difficult, therefore we have tried to make a rough estimation based on a biomass of zooplankton and benthos. A biomass of zooplankton less than 2,5 gr/m$^3$ and benthos less than 5,0 gr/m$^2$ are characteristic for lakes with low food capacity (about 60% from studied), 2,5–6,0 gr/m$^3$ and 5,0–15,0 gr/m$^2$ accordingly – for lakes with moderate food capacity (about 30%), more than 6,0 gr/m$^3$ and more than 15,0 gr/m$^2$ accordingly –




A

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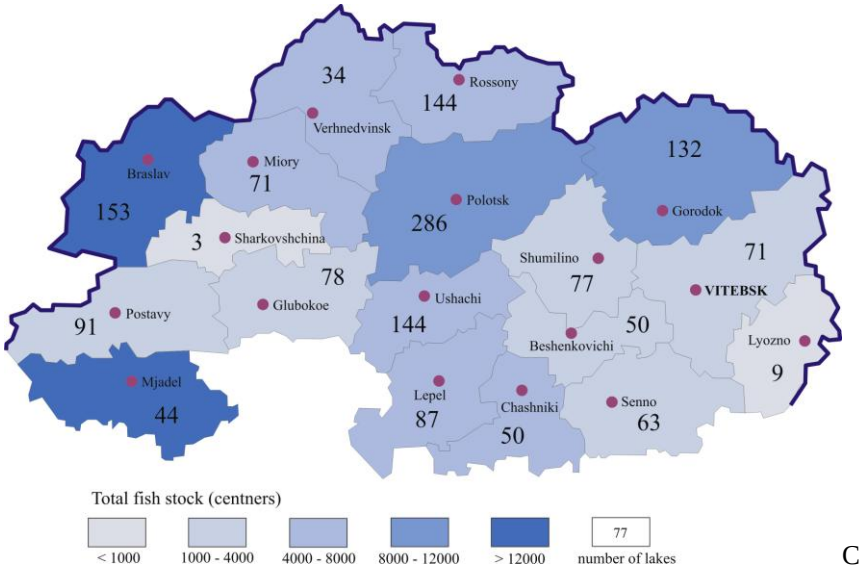


C

Fig. 11. Stocks of animal resources in lakes of the Belarusian Poozerye (A – zooplankton, B – zoobenthos, C – fish)
Rys. 11. Zasoby zwierząt w jeziorach Pojezierza Białoruskiego (A – zooplankton, B – zoobentos, C – ryby)

for lakes with high food capacity (up to 10%). Calculations of zooplankton and benthos stocks for 490 lakes of the region are executed according to average biomass during a summer season.

The basic resources of zooplankton are concentrated in lakes of Braslavsky (170,9 tons), Polotsky (170,4), Ushachsky (138,4) and Lepelsky (107,0) districts; zoobenthos – in lakes of Braslavsky (573,1), Polotsky (369,7) and Ushachsky (358,6 tons) districts (fig. 11).

The basic fish resources are concentrated in lakes of Braslavsky (18 338,1 centners), Myadelsky (12 833,1) and Gorodoksky (9 369,0 centners) districts (fig. 11). A pike, a small fry, an ide, a rudd, a tench, a crucian, a perch, a ruff, a burbot are widespread in lakes. An eel, a pike perch are interesting as a tourist-trade resource. Lakes of crucian-tench (446 lakes with a total area 7 500 hectares) and perch-small fry (804 lakes with a total area 17 400 hectares) types are most widespread in the Belarusian Poozerye, and form about 78% of number and 23,4% of a total area of studied lakes. The commercial fish stock makes 33–115 and 54–92 kg/hectares accordingly. Bream-pike-small fry lakes (64–128 kg/hectares) have more limited distribution (288 lakes with a total area 36 800 hectares) and form about 18% of number and 34,5% of a total area of studied lakes. Bream-pike perch (37 lakes) and whitefish-whitebait (19 lakes) have the least distribution, their commercial stock is up to 120 and 80 kg/hectares accordingly.

The districts with the highest index of animal resources are Polotsky, Braslavsky, Gorodoksky, Rossonsky, Ushachsky, Myadelsky and Lepelsky. The part of lakes resources in a total amount of animal resources exceeds 50% for Braslavsky, Ushachsky, Myorsky, Beshenkovichsky, Lepelsky and Chashniksky districts (fig. 12).

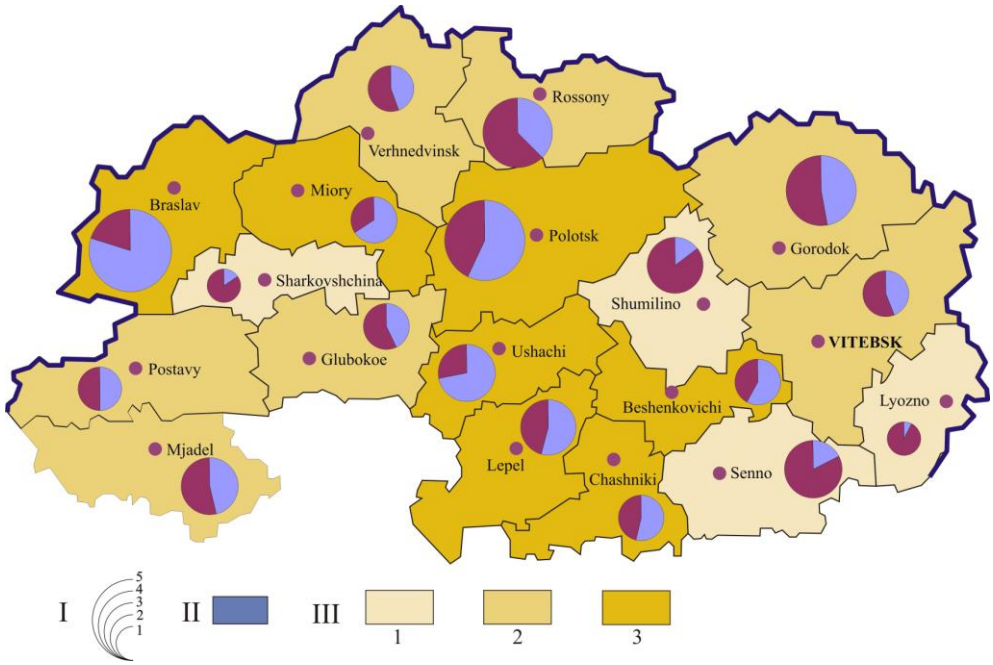


Fig. 12. Stocks of animal resources in the Belarusian Poozerye:
I – animal resources stocks (index): 1 – less than 2,0; 2 – 2,0–5,0; 3 – 5,1–8,0; 4 – 8,1–11,0; 5 – more than 11,0;
II – a part of lakes resources in total amount of animal resources in a district; III – a factor of animal resources ratio:
1 (less than 0,5), 2 (0,5–1,0), 3 (more than 1,0)
Rys. 12. Zasoby zwierząt na Pojezierzu Białoruskim:
I – zasoby świata zwierzęcego (indeks): 1 – poniżej 2,0; 2 – od 2,0 do 5,0; 3 – od 5,1 do 8,0; 4 – od 8,1 do 11,0;
5 – powyżej 11,0; II – udział zasobów jeziornych w ogólnej masie świata zwierzęcego pojezierza;
III – współczynnik wzajemnego stosunku zasobów zwierzęcych: 1 (poniżej 0,5), 2 (0,5–1,0), 3 (powyżej 1,0)

The integrative assessment of size of natural resources potential in lake geosystems of the region (fig. 13) has allowed to allocate districts:

– with very high potential (an index of stocks is more than 40,0): Vitebsky;
– with high potential (30,1–40,0): Braslavsky, Gorodoksky, Polotsky, Myadelsky;
– with moderate potential (20,1–30,0): Verhnedvinsky, Rossonsky, Ushachsky, Chashniksy;
– with low potential (10,0–20,0): Beshenkovichsky, Glubоksky, Lepelsky, Miorsky, Postavsky, Sennensky, Shumilinsky;
– with very low potential (less than 10,0): Lyoznensky, Sharkovshchynsky.

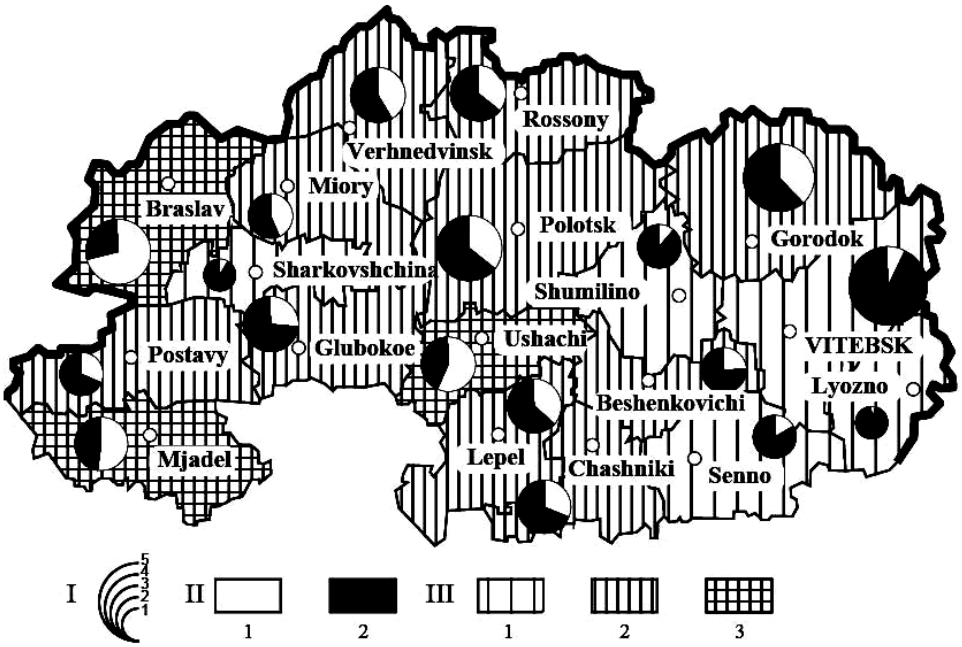


Fig. 13. Differentiation of districts of the Belarusian Poozerye by size of natural resources potential and a ratio of natural resources

I – size of natural resources potential (index): 1 – less than 10,0; 2 – 10,0–20,0; 3 - 20,1–30,0; 4 – 30,1–40,0; 5 – more than 40,0; II – a ratio of resources: 1 – a part of lakes resources in total amount of natural resources of a district, %; 2 – a part of other resources in total amount of natural resources of a district, %; III – integrated factor of natural resources ratio: 1 (less than 0,5), 2 (0,5–1,0), 3 (more than 1,0)

Rys. 13. Zróżnicowanie rejonów Pojezierza Białoruskiego wg wielkości potencjału zasobów naturalnych i ich wzajemnego stosunku:

I – wielkość potencjału zasobów naturalnych (indeks): 1 – poniżej 10,0; 2 – od 10,0 do 20,0; 3 – od 20,1 do 30,0; 4 – od 30,1 do 40,0; 5 – powyżej 40,0; II – stosunek zasobów: 1 – udział zasobów jeziornych w ogólnej masie zasobów naturalnych pojezierza, %; 2 – udział pozostałych zasobów w ogólnej masie zasobów naturalnych pojezierza, %; III – całkowity współczynnik wzajemnego stosunku zasobów naturalnych: 1 (poniżej 0,5), 2 (0,5–1,0), 3 (powyżej 1,0).

Districts with low and very low potential form the most widespread group (43% of the region area), with moderate potential – 19,9%, with high – 37,1%.

Definition of lakes resources part in total amount of natural resources of districts and calculation of integrated factor of natural resources ratio enables an allocation of three groups of districts:

1. with part of lakes resources more than 50% and factor of ratio more than 1,0: Braslavsky, Myadelsky, Ushachsky;
2. with part of lakes resources from 25 up to 50% and factor of ratio from 0,5 up to 1,0: Beshenkovichsky, Gluboksky, Lepelsky, Miorsky, Postavsky, Verhnedvinsky, Gorodoksky, Polotsky, Rossonsky, Chashniksky;
3. with part of lakes resources less than 25% and factor of ratio less than 0,5: Vitebsky, Lyoznensky, Sennensky, Shumilinsky, Sharkovshchynsky.

The majority of districts of the region (68,4% of the territory) is characterized by low degree of use of lakes resources (an index of use less than 10). The districts with partial use of resources (in three and less kinds of activity) prevail among them. Myadelsky, Ushachsky and Sennensky districts (15,5%) are characterized by moderate and complex (more than in three kinds of activity) use of lakes resources. Braslavsky, Rossonsky, Chashniksky districts (16,1%) are characterized by high parameters (more than 20) of lakes resources use (fig. 14).

The most widespread kind of use of lakes resources in the region is commercial fishing and recreational using. The extremely insignificant part of lakes is maintained with a view of water use. Industrial (resource usage persantage – 0,24%) and pond fish (0,13%) water consumption prevail. The largest water-consumers are enterprises of power and pond fish establishments. The extremely insignificant number of lakes is used for household and agricultural water consumption. Lakes resources recreational usage persantage makes hardly more than 8%. Use of biological resources of lakes consists in a preparation of macrophytes (a reed and a flagroot) and zoobenthos (midges larvas). More widespread kind of economic use of biological resources of lakes is fish industry – fish resources usage persantage is about 3%.

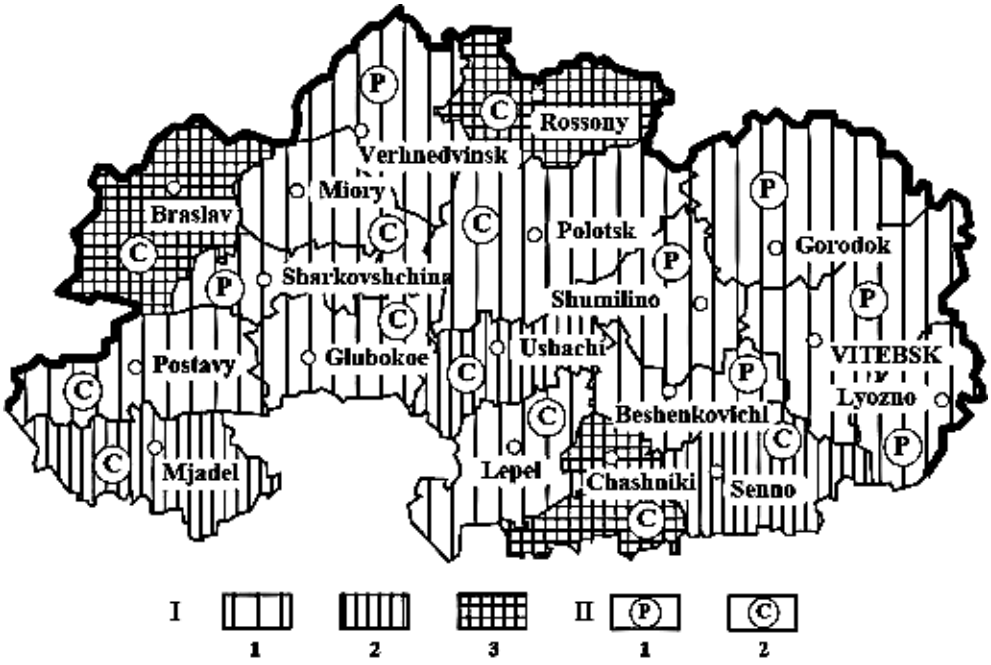


Fig. 14. Differentiation of districts of the Belarusian Poozerye by degree of use of lakes resources:
I – intensity of use: 1 – low , 2 – moderate, 3 – high; II – complexity of use: 1 – partial, 2 – complex
Rys. 14. Zróżnicowanie rejonów Pojezierza Białoruskiego pod względem stopnia wykorzystania zasobów naturalnych jezior:
I – intensywność wykorzystania: 1 – niska, 2 – średnia, 3 – wysoka; II – kompleksowość wykorzystania: 1 – częściowe; 2 – kompleksowe

The resources-economic typology of lake geosystems of the Belarusian Poozerje, that allow to allocate areas with optimum, rather optimum and insufficient level of lakes resources using, was developed on the basis of total size of natural resources potential, a natural resources ratio, intensity and complexity of use of lakes resources (fig. 15).

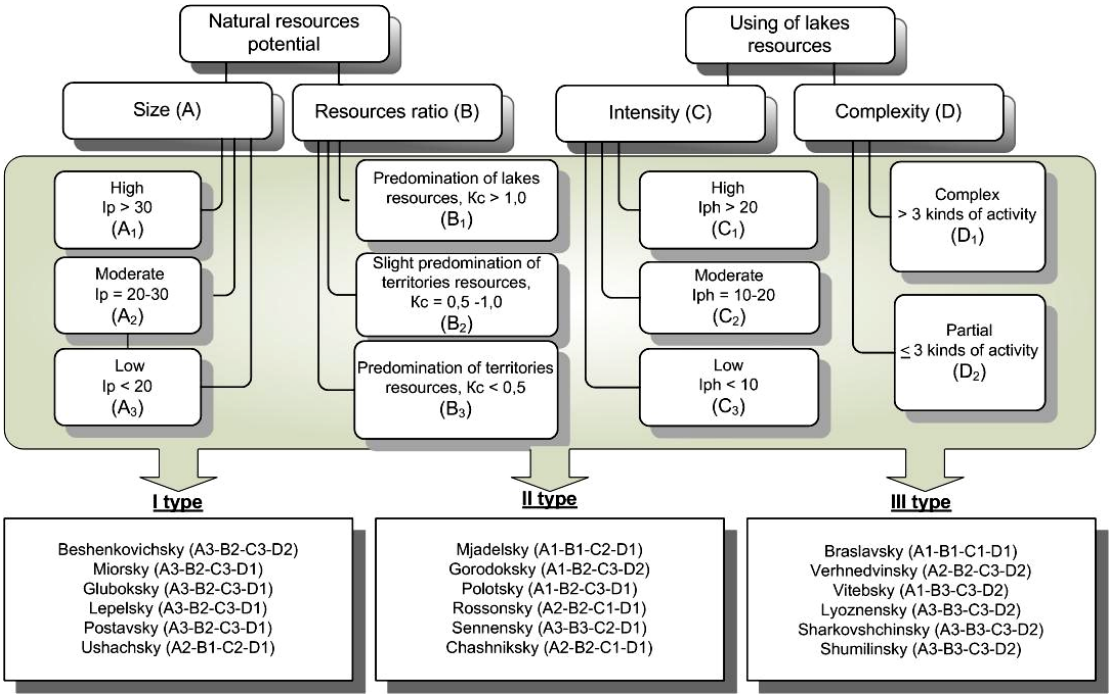


Fig. 15.Resources-economic typology of lake geosystems of the Belarusian Poozerye
Rys. 15. Typologia jeziornych geosystemów Pojezierza Białoruskiego na podstawie zasobów ekonomicznych

Three types of districts are allocated according to the typology:

Type 1. With insufficient use of lakes resources (Beshenkovichsky, Miorsky, Postavsky, Gluboksky, Lepelsky, Ushachsky districts). The change of environmental management aside to an intensification of use of lakes resources is recommended;

Type 2. With rather optimum use of lakes resources (Myadelsky, Gorodoksky, Polotsky, Sennensky, Rossonsky, Chashniksky districts). Regulation of environmental management with partial change of directions and intensity of use of lakes resources is recommended;

Type 3. With optimum use of lakes resources (Braslavsky, Verhnedvinsky, Vitebsky, Lyoznensky, Sharkovshchynsky, Shumilinsky districts). Preservation of an existing level of use of lakes resources with protection and reservation of lakes resources is recommended.

Perspective directions of lakes resources using in the region are defined on the basis of the geoecological assessment and typology of lake geosystems of the region.

It is necessary to consider as well the ecological restrictions directed on rational use of resources and protection of lakes from pollution and degradation. For this purpose the assessment of an ecological status of lakes in the Belarusian Poozerje based on a complex of integrative hydrochemical, geochemical and hydrobiological parameters was made; highly contaminated lakes, needing restoration measures, were defined (fig. 16).

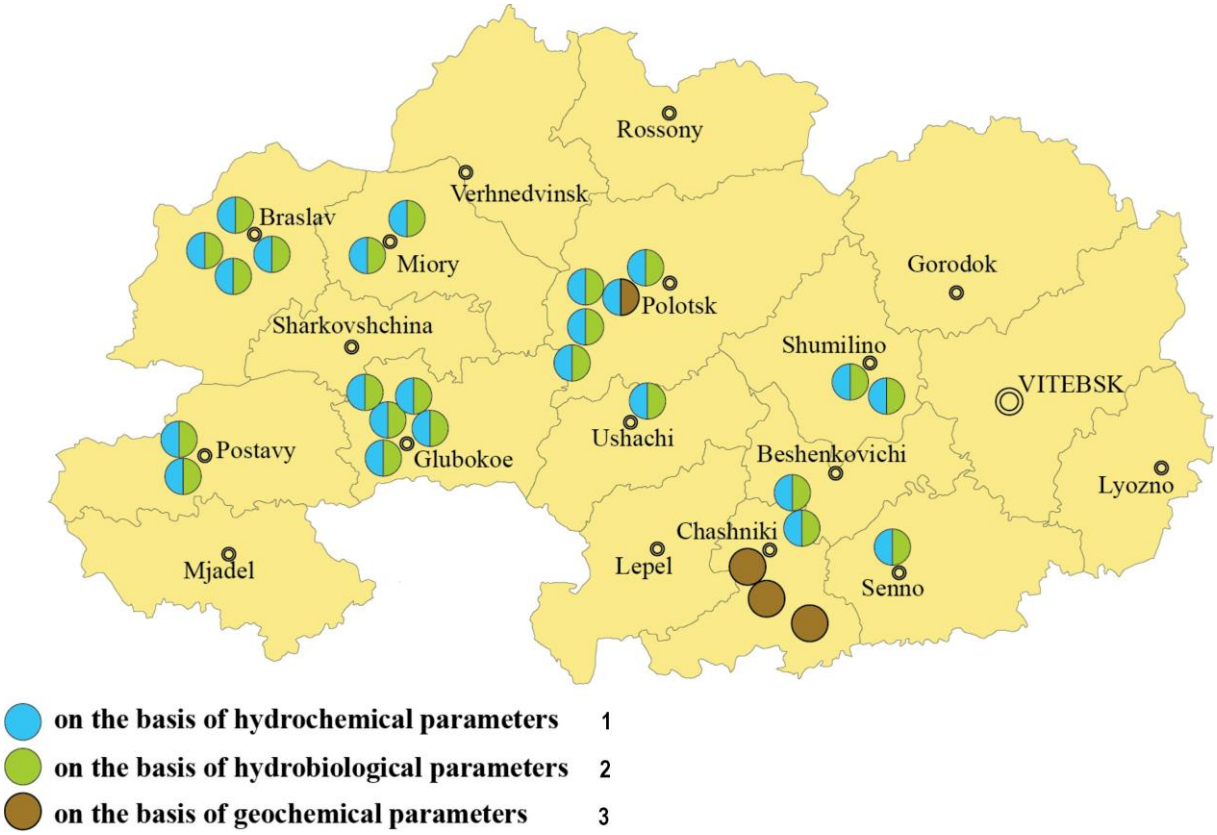


Fig. 16. Polluted and megatrophic lakes of the Belarusian Poozerye
Rys. 16. Zanieczyszczenie i jeziora hipertroficzne Pojezierza Białoruskiego:
1 – na podstawie wskaźników hydrochemicznych, 2 – na podstawie wskaźników hydrobiologicznych,
3 – na podstawie wskaźników geochemicznych

The assessment has shown, that about 90% of studied lakes of the region belong to low- and moderate-polluted, suitable for use (household needs, an irrigation, a recreation, a fishery, as sources of sapropel).

The lakes with strong eutrophication and pollution (up to 5% from the general number of studied lakes), having water of poor quality, need a rehabilitation, and also can find application at extraction of sapropel, an irrigation of technical crops and pastures (lakes with water that contains high concentration of heavy metals should be excluded), separate kinds of a recreation (motor boating for example).

In view of a complex of parameters of an ecological status of lakes and factors causing its change, two groups of highly contaminated lakes of the region are defined: 1) lakes with high speed of eutrophication, megatrophic and polluted lakes in the result of input of nitrogen and phosphorus from point sources; 2) the lakes located near to cities and industrial zones, polluted by **organic compounds** (synthetic surfactants, mineral oil, pitches, asphaltenes), heavy metals, acid atmospheric precipitation.

## CONCLUSION

The executed research is directed on rationalization of use of lakes resources in the Belarusian Poozerye. Results of the assessment allow to define a level of natural resource endowment of administrative districts, a part of lakes resources in natural resources potential and a degree of their use in economic activities, and also to develop recommendations on rational use and protection of lakes, to define priority directions of use of lakes resources and lakes, that are perspective for use. The developed technique of the assessment is scientifically proved, has passed approbation and can form a basis for realization a similar research in other regions.

The social and economic importance of the received results consists in allocation of territories with insufficient and optimum level of use of lakes resources, definition of ways of rationalization and regulation of use, protection and reproduction of natural resources, and also in recommendations on purposeful formation of optimum structure of environmental management in studied region.

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